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EDITORIAL

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Joint virtual issue on recent advances in veterinary cardiac imaging

The year 2020 marks the 125th anniversary of Roentgen's discovery of X-rays,[1] the 60th anniversary of veterinary papers describing the radiographic anatomy of the normal canine heart,[2,3] and the 50th anniversary of the first textbook on canine cardiology.[4] For much of the 20th century, imaging the heart relied on X-rays—either by film radiography or fluoroscopy/angiography. Indeed, Ettinger and Suter's textbook, *Canine Cardiology*, relied solely on radiography and angiography for cardiac imaging (in addition to the complementary diagnostic tests of physical examination and electrocardiography).[4] The advent of echocardiography in the 1950s revolutionized cardiac imaging, followed in subsequent decades by cardiac computed tomography (CT) and cardiac magnetic resonance.

The intent of this joint virtual issue is to highlight recent advances in veterinary cardiac imaging as published in the *Journal of Veterinary Internal Medicine* and *Veterinary Radiology & Ultrasound* in the last 5 years (2014 to 2019). Within this time frame, considerable work by numerous investigators has been performed to enhance our understanding of a complex organ—the heart. Consequently, it was challenging to select a subset of articles as being the most impactful. From someone else's perspective, different but equally excellent articles may have been selected.

In the *Journal of Veterinary Internal Medicine*, nearly all articles from the last 5 years pertaining to cardiac imaging focused on echocardiography—a fact that is understandable given the dominance of this imaging modality in daily cardiology practice. Although we have been performing cardiac ultrasound for decades, there remains a need for accurate and reliable reference intervals to detect deviation from normal. Refinement of normal values in cats has been aided by a large-scale study of nearly 20 000 animals,[5] whereas the article by Visser et al provides narrow reference intervals from 122 dogs evaluated consistently and prospectively using current state-of-the-art equipment by the same sonographer.[6] Reference intervals are also critical for accurate assessment of the equine heart, which has been enhanced by work from the University of Zurich.[7] Many articles focused on the most common heart disease of dogs—myxomatous mitral valve degeneration—highlighting the prognostic value of mitral regurgitation severity[8] as well as improved methods to quantitate both the regurgitant orifice[9,10] and degree of cardiac remodeling.[11] Advanced analysis of the geometry of the mitral valve by 3-dimensional (3D) echocardiography also expands our understanding of the disease phenotype.[12] Although advanced 3D echocardiography is limited primarily to research centers, point-of-care ultrasound was demonstrated to be a useful screening tool to overcome the challenges of detecting heart disease in cats by nonspecialists practitioners.[13] The last 5 years also demonstrate an increased focus on the right ventricle,[14-16] the side of the heart that has been largely ignored in the past. Further focus on the right ventricle has sought to improve our understanding of the utility of echocardiography to estimate pulmonary arterial pressure and enhanced our appreciation of pulmonary hypertension as a cause of morbidity in animals.[17,18] Although less common than acquired canine valve disease or feline cardiomyopathy, congenital heart disease remains a source of morbidity and mortality in animals. Improved measures to quantify severity of pulmonary valve stenosis[19] and a novel method to predict development of subaortic stenosis[20] can be found in these selected articles.

The increasing availability of CT and magnetic resonance imaging (MRI) in veterinary practice has revitalized efforts for evaluation of the heart within the diagnostic imaging community, as reflected by the majority of the articles published in the journal *Veterinary Radiology & Ultrasound* (VRU) during the period of 2014 to 2019. Although echocardiography is commonly conducted with the patient awake, sedation or general anesthesia is typically necessary to allow for patient restraint during the image acquisition using CT and MRI. The effect of different drug protocols may alter the functional or anatomical variables determined from CT and MRI examinations and has therefore been the subject of several publications.[21-23] Similarly, cross-modality correlation and the need for establishment of reference values has prompted several publications,[23-26] including the first cross-sectional study published in VRU in 2005 by MacDonald et al using MRI to quality left ventricular mass compared to echocardiography in cats.[27] Exact timing of the image acquisition in relation to the contrast medium highlighting the vascular bed of interest for angiography studies generally requires a power injector; specific bolus tracking software allows patient-specific timing of the image acquisition which has been addressed in a review article.[28] Besides anatomical depiction, optimized vascular contrast during angiography studies allows detection of luminal alterations such as thrombi.[29] The heart and especially the coronary arteries of our companion animals are much smaller compared to our human counterparts, and heart rates are much higher. These factors indicate the need for high spatial resolution while maintaining rapid scan acquisition; hence, several investigations

used advanced multidetector CT units (eg, 64 MDCT) and high-field MRI (eg, 3T) to establish the feasibility to image these small and fast-moving structures.[21-23] Electrocardiographic (ECG) gating is used to match the phase of image acquisition to the phase of the cardiac cycle and is necessary to perform functional evaluation of the heart, using planar and volumetric measurements.[28] Although ECG gating is routinely used in human patients for evaluation of the coronary arteries, the use of computed tomographic angiography for depiction of the coronary arteries in Bulldogs has been demonstrated without ECG gating,[30] making the technique available to a wider community because not all scanners are able to be equipped with ECG gating and the installation of the necessary soft- and hardware can be cost prohibitive.

Computed tomography in particular has been used for a detailed global assessment of thoracic structures beyond the heart, to determine secondary cardiac effects from thoracic changes, and to evaluate sequelae to cardiac disease and extracardiac vascular anomalies, allowing for accurate diagnosis and treatment planning.[24-26,31] In contrast, MRI is currently predominantly used for cardiovascular assessment.[32] Advanced image postprocessing and analysis software that allows generation of subjective numeric parameters for cardiac as well as pulmonary vascular assessment has found initial use in veterinary applications.[33]

The advancements in clinical knowledge generated especially from echocardiography, CT, and MRI offer exciting new insights into thoracic cardiovascular pathophysiology and lay fertile grounds for future collaborations between diagnostic imaging and cardiology specialists.

Brian A. Scansen[1]
Randi Drees[2]

[1]*Department of Clinical Sciences, Colorado State University, Fort Collins, Colorado*
[2]*Department of Clinical Sciences and Services, The Royal Veterinary College, Hatfield, United Kingdom*

Correspondence
Brian A. Scansen, Department of Clinical Sciences, Campus Delivery 1678, Fort Collins, CO 80528.
Email: brian.scansen@colostate.edu
Randi Drees, Department of Clinical Sciences and Services, Hawkshead Lane, AL9 7TA Hatfield, United Kingdom.
Email: rdrees@rvc.ac.uk

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ORCID

Brian A. Scansen https://orcid.org/0000-0001-7427-2402
Randi Drees https://orcid.org/0000-0003-3050-072X

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